
**पृथ्वी और रॉकफिल डैम, मैसनरी डैम और
कंक्रीट ग्रेविटी बांधों के ग्राउट पर्दे के
डिजाइन के लिए दिशा-निर्देश**

**Guidelines for the Design of Grout
Curtains for Earth and Rock Fill
Dams, Masonry Dams and
Concrete Gravity Dams**

ICS 93.020

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Foundation and Foundation Treatment Sectional Committee had been approved by the Water Resources Division Council.

There are various measures for seepage control which are given in IS 8414 : 2014, one of which is grout curtain. This standard covers the design of grout curtain for earth and rockfill dams, masonry dams and concrete gravity dams.

Design requirements for a grout curtain depend on its function, for example, when the grout curtain is designed to function as the principal measure of seepage control and it constitutes the main seepage barrier, it shall be of adequate depth and width and the permeability within the grouted zone shall be reduced to acceptable limits. On the other hand the grout curtain may be considered as a complementary measure of other seepage control measures. In such cases the curtain is essentially an exploratory line of closely spaced holes aimed at sealing the wider and more open cracks and voids so that the efficacy of the system is not impaired by excessive concentrated seepage along the major cracks joints and voids. The method of grouting is covered in IS 6066 : 1994.

This standard covers design of grout curtain for earth and rockfill dams, masonry dams and concrete gravity dams.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

GUIDELINES FOR THE DESIGN OF GROUT CURTAINS FOR EARTH AND ROCKFILL DAMS, MASONRY DAMS AND CONCRETE GRAVITY DAMS

[First Revision, amalgamating Part 1 and Part 2]

1 SCOPE

This Indian Standard provides the following:

- a) Guidelines for the design of grout curtains in alluvium and rock when used as principal measure of seepage control; and
- b) Guidelines for the design of grout curtains which are used as principal measure of seepage control for masonry and concrete dams founded on rock mass.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

<i>IS No.</i>	<i>Title</i>
IS 8414 : 2014	Guidelines for design of under-seepage control measures for earth and rock fill dams (<i>first revision</i>)
IS 6066 : 1994	Pressure grouting of rock foundation in river valley projects — Recommendations (<i>second revision</i>)

3 GROUT CURTAINS IN ALLUVIUM

3.1 Choice of Number of Rows of Grout Holes

In alluvium and other type of pervious soils, multiple rows of holes are necessary for effective sealing when the curtain constitutes the principal seepage barrier. The choice of numbers of rows of holes is governed by the following considerations:

- a) In heterogeneous formations effective sealing may be achieved on the central row or rows, the outer rows being employed primarily to block the

open passage and seal the larger voids so that over travel of the more fluid grout injected through the central rows is prevented; and

- b) The curtain width should be adequate to ensure adequate resistance to leaching and internal erosion.

3.2 Resistance of Grout to Internal Erosion and Leaching

3.2.1 The ratio of the width of the curtain to the hydraulic head across the curtain depends on the nature of the grout material and the formation treated by the grout. Clay cement and bentonite cement grout injected into coarse sand and gravel are known to have withstood hydraulic gradients as high as 7 : 1. Prolonged laboratory tests of one year duration have indicated virtual permanence of the clay-cement-bentonite grout for specimens of grouted sand and gravel subjected to gradients as high as 20. On the other hand the softer bentonite silicate grouts used for treatment of medium sand may be eroded at gradients of the order of 10. For permanent curtains hydraulic gradient for bentonite silicate grout have been restricted to 3 : 1. Bentonite silicate grouts should be used with caution since their behaviour is very much dependent on the nature of bentonite, and its reaction with the fluidifier and salts in the soil.

3.2.2 Silicate aluminate gels are known to be stable and are known to withstand hydraulic gradients of 4 : 1 or even higher. Data presently available indicate that acrylamide grout are permanent. The permanence of other types of grouts need to be investigated, and their application is not advised for important and permanent curtains. For permanent curtains choice of grout materials is generally limited to clay cement, bentonite and silicate aluminate grouts.

3.3 Curtain Width

The curtain width should be chosen on the basis of following criteria:

- a) The curtain width at the core contact should match the core base, usually width in the range of 1/3 to 1/5 head is provided (*see Fig. 1*);

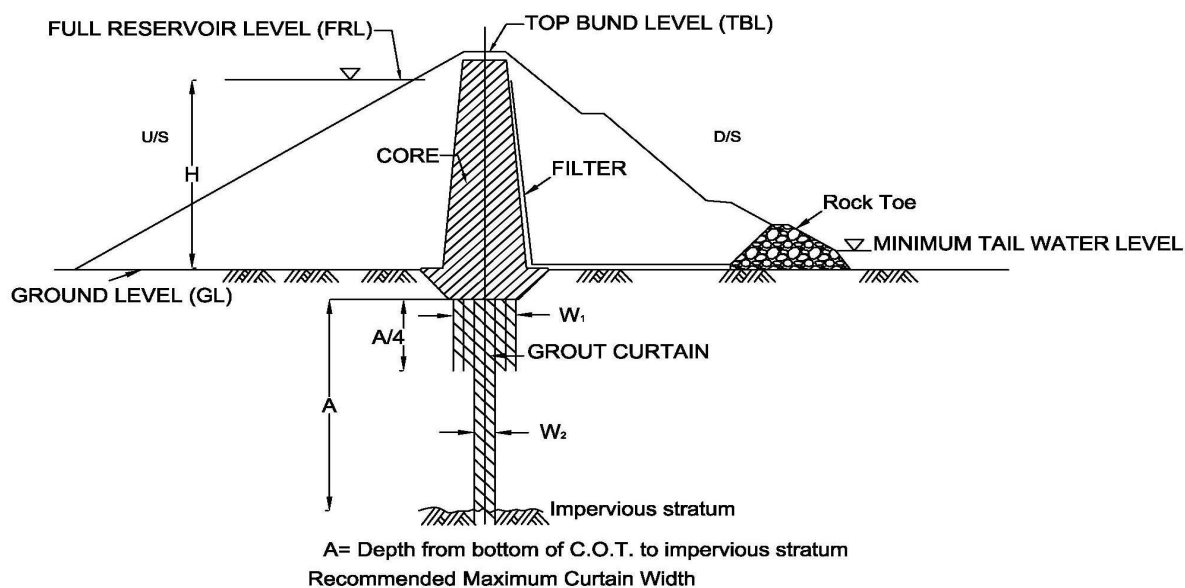


FIG. 1 GROUT CURTAINS IN PERVIOUS SOILS

- b) The main curtain should extend to rock or impervious stratum and the width should be reduced from the width at core contact to the main curtain width. Usually this is achieved in a zone of about one fourth the depth of the pervious alluvium;
- c) The main curtain should have two or more rows depending upon the requirements of strata. For clay cement silicate aluminate grouting the main curtain should have a width of $1/7$ head; and
- d) The residual head, downstream of the curtain measured as excess head with regard to tail water should be 20 percent or lower of the total head from tail water to head water. This reduction in head is achieved by appropriate choice of curtain width and by bringing about sufficient of permeability in the curtain width. Usually grouting is effective when the post-grouting permeability values are brought down to one hundredth of initial values.

4 GROUT CURTAINS IN ROCK

4.1 Curtain Width

4.1.1 For effective control of seepage in large zones of fractured and jointed rocks it is necessary to treat the contact of the core and rock foundation by blanket grouting. The depth of blanket grouting hole should be at least 6 m.

4.1.2 The normal practice of splitting the spacing starting with an initial spacing of 6 to 12 m is recommended for each of the rows. The final spacing would be related

to the spacing of joints and normally 3 metres spacing may be necessary, but special geological condition may require closer spacing.

4.1.3 The main curtain would consist of one or more rows of holes. In the first row grouting operations are carried out by split spacing method. If the permeability can be brought down to 5 lugeon with a final spacing of 3 m or larger, a single line curtain would be adequate. If further drilling and grouting of holes at closer spacing is required, two line curtains should be preferred.

4.2 Types of Grout in Rock

Normally for grout curtains in rock, neat cement grout should be used and if admixtures are used to reduce cement consumption, only non-colloidal fillers such as fine sand, fly ash may be used. For grout curtains in rock colloidal admixtures such as bentonite would not be normally permitted since the addition of bentonite/clay would reduce the resistance of grout to internal erosion and leaching. Use of such admixtures should be combined with sand in small quantities, about 2 percent by weight of cement, to obtain a more pumpable grout mix.

4.3 Depth of Curtain

4.3.1 The depth of the curtain shall be related to the design of the drainage system and the depth to an essentially impervious and non-erodible rock formation. In stratified rock and in massive igneous or crystalline metamorphic rock an impervious formation may often be established at shallow depth below rock

surface and 3 metres would be sufficient penetration of the grout curtain into such formations.

4.3.2 Grouting cannot be relied upon to prevent internal erosion in clayey or silty gauged zones and solution cavities filled by heterogeneous mixture of clay, silt, sand and rock fragments.

4.3.3 In such cases, it is essential to excavate and backfill seams in the entire core contact zone and blanket if necessary special care is needed when material filling seams consists of silt and dispersive clay vulnerable to erosion.

4.3.4 The grout curtain should normally extend to relatively impervious rock of permeability 3 lugeon or less. When this cannot be realized due to deep pervious formations the curtain should extend to a depth ranging from $H/3$ to H with reference to the core and core rock contact. The greater depth may be necessary up to reservoir head when the rock contains seams and defects vulnerable to internal erosion.

5 DESIGN CONSIDERATION FOR MASONRY AND CONCRETE GRAVITY DAMS

5.1 Geological Considerations

5.1.1 The data already obtained from the exploration of the foundation should be analysed to assess the characteristics of foundation rocks and the location and orientation of faults, seams, cavities, joints and bedding planes and discontinuities.

5.1.2 The permeability values of foundation strata at various depths should be used for the design since the stages and spacing of the holes for grouting should be based on this data.

5.2 Drilling of Grout Holes

Percussion drills can be used for drilling the grout holes, provided the foundation rock is of a type that will produce granular cuttings, rather than slimes. In case of rocks having weaknesses such as faults and seams it is recommended that at least one hole should be bored with suitable boring machines which are capable of recovery of rock cores and which will facilitate inspection of bore hole walls. Diamond core drilling permits the examination of cores and the location of seams by means of a TV borehole camera.

5.3 Inclination of Grout Holes

The holes may be either vertical or inclined. The orientation, plan and inclination of grout holes depend upon the type of joints and other discontinuities in the foundation rock. The most common practice is to drill holes inclined towards upstream at 5 to 10 degrees with the vertical.

5.4 Spacing of Grout Holes

Single line grout curtains are generally used. The usual practice is to try a widely spaced system of primary holes at a spacing of 6 to 8 m, followed by secondary and tertiary holes at a progressively smaller spacing till the desired results are obtained. However, hole spacing less than one meter should be avoided.

5.5 Depth of the Grout Curtain

The depth of the grout curtain depends upon the type and conditions of the rock mass with respect to its permeability. The following empirical criteria may be used as a guide which is based on going practice:

$$D = 2/3 H + 8$$

where,

D = Depth of the grout curtain, in m; and

H = Height of reservoir water, in m.

6 GROUT PROCEDURE

6.1 The procedure for grouting as laid down in IS 6066, should be followed.

6.2 Curtain grouting is normally done from the foundation cum drainage gallery after masonry/concrete is laid up to half of the design height or 20 m from the bottom of the gallery, whichever is earlier. However in special cases an additional grout curtain can also be provided at the heel of the dam.

6.3 Drainage holes should be drilled in the foundation gallery. Drainage holes should, however, not be drilled in the foundation gallery till curtain grouting is completed within 30 m from the location of the drainage holes.

6.4 Efficacy of Grout Curtain

This should be evaluated by results of permeability tests during drilling of secondary/tertiary holes as given in IS 6066.

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